Henderson Basin 44 CSO Reduction Project

Operational Noise Assessment Technical Memorandum

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1.0 Introduction

This Technical Memorandum provides an operational noise assessment for the Henderson Basin 44 CSO Reduction Project which addresses combined sewer overflows (CSO) in southeast Seattle. A separate Technical Memorandum addresses construction noise.

The City of Seattle is required to reduce the number of untreated overflows from its combined sewer system to meet State and Federal regulations. In a combined sewer system, wastewater (from homes and businesses) and stormwater (from rooftops and streets) flow into a single pipeline. During heavy rains, wastewater and stormwater volumes can exceed the system's capacity, causing a CSO into the nearest waterway. CSOs are a public health concern because they carry pollutants—primarily untreated sewage and stormwater runoff—into the receiving water bodies.

Reducing CSOs from Henderson Basin 44 is one of the highest priorities for Seattle Public Utilities (SPU), the department that operates and maintains the City's sewer system. From 1998 to 2011, Basin 44 had approximately 17 CSO events per year, with an average annual volume of approximately 37 MG of untreated CSO discharge. SPU's objectives are to reduce the volume and frequency of Basin 44 CSOs and to meet State law and regulations that limit CSOs to a long-term average of no more than one untreated discharge per outfall per year.

Three alternatives have been identified and will be evaluated in an environmental impact statement (EIS):

- **Alternative 1 - Storage under Seward Park Tennis Courts:** Alternative 1 consists of four main elements: 1) a 2.4 million-gallon CSO storage tank and associated infrastructure, 2) replacing an existing CSO outfall, 3) shoreline treatment, and 4) a transfer of grant protections and upland landscaping enhancements. The first three elements are located in Seward Park. The fourth element, the transfer of grant protections and upland landscaping enhancements, is located in a portion of Lake Washington Boulevard Park approximately one mile north of Seward Park near the intersection of Lake Washington Boulevard South and 53rd Avenue South.

  The CSO storage tank is the primary focus of the Henderson Basin 44 CSO Reduction Project and is the element that will result in reduced CSOs. The other three elements are included in the project since they are necessary to achieve successful implementation of the CSO storage tank.

The 2.4 million-gallon CSO storage tank would be located under the tennis courts and an adjacent parking lot (Parking Lot 1) in the southwest part of the park, adjacent to the Lake Washington shoreline. The CSO storage tank would hold excess combined sewage until system capacity was available to convey it to treatment facilities. The CSO storage tank requires associated infrastructure such as a facilities vault and sewer pipelines. Upon completion of construction, the tennis courts and parking lot would be restored.

- **Alternative 2 - Storage under Seward Park Parking Lot:** Alternative 2 is the same as Alternative 1, except that the CSO storage tank would be sited in a different location. The CSO storage tank would be located under a parking lot (Parking Lot 2) approximately 300 feet east of the Alternative 1 site. The parking lot is adjacent to the Lake Washington shoreline. Upon completion of construction, the parking lot would be restored.

- **No Action Alternative.** Under the No Action Alternative, the CSO storage tank and associated infrastructure would not be built. The shoreline treatment and the transfer of UPARR grant protections would also not be implemented. The existing CSO outfall would eventually be replaced because it is in poor condition and was previously recommended for replacement. The outfall replacement is expected to occur between 2015 and 2020, under the planned SPU Outfall Rehabilitation Program.

This Technical Memorandum only covers Alternative 1, because it was selected as the preferred alternative. This Technical Memorandum does not cover the area in Lake Washington Boulevard Park associated with the transfer of grant protections and upland landscaping enhancements because no noise generating equipment would be located in that area.

2.0 Characteristics of Noise

Sound travels through the air as waves of minute air pressure fluctuations caused by vibration. In a free field, sound waves travel away from the noise source as an expanding spherical surface. As a result, the energy contained in a sound wave is spread over an increasing area as it travels away from the source. This results in a decrease in loudness at greater distances from the noise source.

Sound level meters measure the actual pressure fluctuations caused by sound waves and record separate measurements for different sound frequency ranges. The decibel (dB) scale used to describe sound is a logarithmic scale that accounts for the large range of sound pressure levels. Most sounds consist of a broad range of frequencies. Several frequency weighting schemes have been used to develop composite decibel scales that approximate the way the human ear responds to noise levels. A difference of 2 or 3 dB can be detected by some people. A 5 dB change would be perceived by most people under normal listening conditions.

The preferred frequency-weighting scheme for environmental noise measurements is the A-weighting network. This is an approximation of the loudness perceived by human ears at different frequencies. The human ear does not hear all frequencies equally. In fact, the human hearing organs of the inner ear deemphasize very low and very high frequencies. The A-weighted decibel (dBA) is used to reflect this selective sensitivity of human hearing.

This scale puts more weight on the range of frequencies where the average human ear is most sensitive, and less weight on those frequencies we do not hear as well. Often the decibel unit (dB) could mean either A-weighted or unweighted, therefore it is often conventional to indicate unweighted decibels by dBL, or linear-weighted decibels which is the same as saying unweighted.

In acoustics, a decibel may be indicating one of several physical acoustic measures. For environmental noise assessment, the sound pressure level and the sound power level are commonly discussed. It is often helpful to relate these measures of a decibel with a source or receiver.

- Sound source: measured with sound power level
- Receiver (microphone or ear): measured with sound pressure level

Sound power describes the sound emission characteristics of a source. Sound power levels are often abbreviated SWL, where the W refers to watts, the fundamental unit of power. Sound power is a characteristic of the sound source, irrespective of its environment and does not depend upon distance. Therefore, it is possible to use the sound power levels to calculate the effect of a source at a receiver through a multitude of potential environments and transmission paths.

Sound pressure is what measurement microphones can detect and what ears can sense. Most measurements are of sound pressure levels (SPL). It is a measurement of the tiny fluctuations in pressure generated by a vibrating source, whether that source is the vocal chords in a human or a running car engine. The sound pressure at a receiver depends upon the transmission path, especially the distance between the source and receiver.

When distance is the only factor considered, sound levels from isolated point sources of noise typically decrease by about 6 dB for every doubling of distance from the noise source. When the noise source is a continuous line (for example, vehicle traffic on a highway), sound levels decrease by about 3 dB for every doubling of distance away from the roadway. In traffic studies, an attenuation rate of 4.5 dB per doubling of distance is often used when the roadway is at ground level and the intervening ground is effective in absorbing sound (for example, ground vegetation, scattered trees, clumps of bushes). When the roadway is elevated, 3 dB noise attenuation per doubling of distance is used because the sound-absorbing effects of the intervening ground are limited.

Noise levels at different distances can also be affected by factors other than the distance from the noise source. Topographic features and structural barriers that absorb, reflect, or scatter sound waves can increase or decrease noise levels. Atmospheric conditions (wind speed and direction, humidity levels, and temperatures) can also affect the degree to which sound is attenuated over distance.

Reflections off topographical features or buildings can sometimes result in higher sound levels (lower sound attenuation rates) than would normally be expected. Temperature inversions and altitude changes in wind conditions can also diffract and focus a sound wave to a location at considerable distance from the noise source. Focusing effects are usually noticeable only for very intense noise sources, such as blasting operations. As a result of these factors, the existing noise environment can be highly variable depending on local conditions.

3.0 Noise Regulations and Criteria

The Seattle Municipal Code (SMC 25.08) establishes limits on the levels and durations of noise crossing property boundaries. Allowable maximum sound levels depend on the land use zoning designation of the noise source and the zoning designation of the receiving property. The SMC noise limits are shown in Table 1.

It is important to note, however, that the sounds created by motor vehicles, such as traffic on Lake Washington Boulevard South or Seward Park Avenue South and other roads near the alternative sites, are exempt from the noise limits specified in Table 1 (SMC 25.08.480).

Table 1. Seattle Municipal Code Exterior Sound Levels (dBA)

District of Noise Source	District of Receiving Property		
	Residential Day/Night*	Commercial Day	Industrial
Residential	55/45	57	60
Commercial	57/47	60	65
Industrial	60/50	65	70

Source: SMC, Chapter. 25.08.410 Exterior Sound Level Limits at the property line

* Nighttime is defined as 10 PM to 7 AM on weekdays, but extends to 9 AM on Saturday and Sunday, according to SMC 25.08.420

4.0 Existing Noise Environment

To characterize existing noise conditions, noise monitoring was conducted at nine locations in the vicinity of the Alternative 1 and Alternative 2 sites in Seward Park. Short-term (10-minutes at each location) noise monitoring was conducted at each monitoring location. Noise monitoring was conducted between 10:00 a.m. and 1:00 p.m. on June 15, 2011. Monitoring locations are shown in Figure 1.

Table 2 shows the results of noise monitoring at the Alternative 1 and 2 locations and adjacent areas. Existing noise levels in Seward Park are low because of low vehicular traffic volumes in the park and the absence of other major noise sources, such as industrial facilities. Measured noise levels at residential locations outside of the park are somewhat higher due to occasional pass-by traffic on Lake Washington Boulevard South, Seward Park Avenue South, and Lakeshore Drive South. Measured noise levels at all locations were typical of quiet, urban neighborhoods.

Table 2. Noise Monitoring Data – Locations and Results

Monitoring Location	Site Description	Date	L_{EQ}[a]
ML-1	East end of Alternative 2 Parking Lot Site	6/15//2011	46
ML-2	Picnic area, north side of Alternative 2 Parking Lot Site	6/15/2011	37
ML-3	Northeast corner of Lake Washington Boulevard South and Parking Lot entrance	6/15/2011	37
ML-4	South end of Alternative1 Tennis Court Site	6/15/2011	37
ML-5	West side of Alternative 1 Tennis Court Site	6/15/2011	42
ML-6	Residential – Southwest corner of Seward Park Avenue South / South Juneau Street intersection	6/15/2011	60
ML-7	Residential – Seward Park Avenue South	6/15/2011	60
ML-8	Residential – Southwest corner of Seward Park Avenue South / Lakeshore Drive South intersection	6/15/2011	62
ML-9	Residential – Lake Shore Drive	6/15/2011	55

Notes:
[a] Equivalent-average sound pressure level

5.0 Noise Analysis

5.1 Input Data

HDR evaluated project operational noise using Cadna-A, a three-dimensional acoustical modeling software based on international acoustical standards. HDR imported a DXF file into Cadna-A; and the file showed the footprint of the area surrounding the proposed project site. Noteworthy features in the DXF file include the outlines of nearby homes, property lines, topographic lines (showing the terrain feature between the homes and the project site), and HVAC ducts for inlet and exhaust fans both in Parking Lot 1 (flush with the ground) and in the grassy area near the base of the terrain slope. The file also shows the existing tennis courts, the proposed CSO storage tanks, and other features of the immediate area.

HDR modeled fan-blade-induced noise exiting the intake and exhaust ducts from the five fans shown below. Noise from the motors that drive the fans was not included in this analysis because they have a negligible noise contribution compared to the fan-blade noise.

- Two 1 horsepower (hp) 650 cubic feet per minute (cfm) supply air Heating, Ventilating and Air-Conditioning (HVAC) fans (one for each of the Facility Vault Rooms)

- Two 1 hp 750 cfm exhaust air HVAC fans (one for each of the Facility Vault Rooms)

- One 7.5 hp 2000 cfm odor control exhaust fan

The fan noise emissions data are from Aerovent (a Twin City Fan company), for the odor control fan. HDR estimated noise emissions data for the HVAC exhaust and supply fans from the Handbook of Noise Control (edited by Cyril M. Harris, 2nd edition). Table 3 presents the sound power levels (SWL) used to assess noise from the fans.

Table 3. Unweighted Fan Sound Power Levels

Fan Name	Sound Power Level Spectrum (dBL)								Overall	
Frequency Band (Hz)	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**dBA**	**dBL**
Odor control fan[a]	103	97	93	95	92	82	79	80	96	105
HVAC Supply fan[b]	103	97	106	90	84	79	78	73	98	108
HVAC Exhaust fan[b]	104	98	107	91	85	80	79	74	99	109

Note: see Section 2 for discussion of the relationship between sound power level and sound pressure level.

[a] From Aerovent

[b] From Handbook of Noise Control, Table 27.1 and related text

The odor control fan duct would terminate at-grade in Parking Lot 1 (covered by a metal grate). Per the manufacturer, the odor control fan sound power levels were reduced by 20 dB to account for the loss that occurs in the duct work at both the inlet and outlet. Outlet noise from this fan has to pass through 3,000 pounds of carbon pellets. HDR assumed a loss of 20 dB due to acoustical absorption by the carbon pellets. Because the odor control fan discharges at-grade in Parking Lot 1 (an acoustically reflective plane), a 6 dB adjustment (increase) was applied to account for the effects of the reflective plane.

The HVAC fan ducts would terminate in above-ground enclosures with approximate dimensions of 1 cubic meter. The current model includes non-acoustic louvers at the duct termini, but these louvers provide negligible noise attenuation. Noise from the centrifugal HVAC fans has to travel through ductwork before it reaches the outdoor environment. This ductwork has not yet been designed; therefore a detailed HVAC noise model could not be created. In lieu of that, HDR assumes that approximately 20 decibels of fan noise will be lost in the ducts (based on data from the odor control fan manufacturer). Therefore, 20 decibels were subtracted from the HVAC fan inlet and outlet sound power level spectrums shown in Table 3 above, and modeled fan noise in Cadna-A. The HVAC fan duct termini were modeled as point sources one meter above the ground.

The ground elevation at the noise sources, the slope of the nearby terrain feature, and the ground height at the nearby residential property lines were determined from engineering work performed for the Henderson North CSO Reduction Project Facility Plan. These elevations were entered into Cadna-A to define the topography of the study area.

Cadna-A was configured to calculate noise levels throughout a Cartesian coordinate grid that HDR created and overlaid upon the DXF file using Cadna-A. The model uses this information to calculate noise contour lines. Cadna-A was also configured to calculate noise levels at discrete receptors HDR placed along the nearby residential property lines. HDR assigned these receptors a height of approximately 5 feet above the ground, and placed one in each of the back yards along the property line. The model assumed that the ground between the noise sources and the nearby property line receptors is acoustically absorptive.

5.2 Results

Initial modeling results indicate that noise emissions from the fans, modeled as described above, would comply with the noise limits shown in Table 1 at the nearest residential property lines. However, analysis results without mitigating strategies indicate that project operational noise levels may exceed the maximum allowable levels inside the park (in Parking Lot 1, in the tennis courts, and near the duct termini). Cadna-A results indicated that the HVAC fans were the loudest contributors to the calculated exceedances in the park. Therefore, in order to comply with SMC sound limits, HDR considered mitigation strategies.

Two potentially effective mitigation strategies for fan noise attenuation are acoustical louvers at the duct termini, or and duct liner inside the lengths of ducts. HDR modeled acoustical louvers on the HVAC duct inlets and outlets and also on the odor control fan inlet. Acoustical louvers were chosen over duct liner because the effectiveness of duct liner is dependent upon duct length, dimensions, and turn configurations, whereas non-acoustic louvers were already included in the model and acoustical louvers are a relatively simple upgrade. HDR configured the Cadna-A model to simulate the noise reduction provided by Kinetics Noise Control Corporation louver model VAL/2. Table 4 presents the noise reduction performance provided by this louver.

Table 4. Acoustic Louver Noise Reduction (dB)

Type	Thickness (in)	Noise Reduction (dB) Frequency Band (Hz)						
		125	250	500	1000	2000	4000	8000
VAL/2	6	7	11	15	16	17	18	18

Revised analysis results, using the acoustic louver shown above, indicate that project operational noise levels are expected to comply with maximum allowable noise levels in the SMC. Analysis results also indicate that project operational noise levels at the residence property lines are expected to be at or below noise levels measured in Parking Lot 1 and near the tennis courts.

Table 5 presents these results and compares them to the existing ambient noise level and to the SMC residential noise limits. Property line receptors are listed from north to south, representing the property lines at the back yards of homes adjacent to the project site. The highest calculated noise levels occur at the property line of homes closest to the HVAC duct termini and odor control duct inlet.

Table 5. Noise Analysis Results

Receptor	Existing Measured dBA[(a)]	Project Operational dBA[(b)]	Expected Total dBA[(c)]	Limits Day/Night dBA[(d)]	Exceedances Day/Night dBA[(e)]
R1	37	13	37	55/45	0/0
R2	37	16	37	55/45	0/0
R3	37	19	37	55/45	0/0
R4	37	24	37	55/45	0/0
R5	42	25	42	55/45	0/0
R6	42	21	42	55/45	0/0
R7	42	22	42	55/45	0/0
R8	42	19	42	55/45	0/0
R9	37	17	37	55/45	0/0
R10	37	10	37	55/45	0/0

Notes:

(a) Existing noise level from nearest baseline measurement. Described in Section 4.0.

(b) Project operational noise levels calculated from Cadna-A model, includes incorporation of Kinetics Noise Louver. Described in Section 5.2

(c) Expected total noise level due to combination of existing plus project operational noise. Due to the logarithmic nature of the decibel scale, existing noise is nominally unaffected unless project operational noise is within 10 dB of the existing noise level.

(d) SMC residential noise limits.

(e) Exceedance of expected project operational noise level over the SMC residential noise limits.

As shown in Table 5, the project operational noise levels:

- Are anticipated to be much lower than existing measured noise levels.
- Are not anticipated to increase the expected total noise levels above existing measured noise levels (see footnote c in Table 5 for explanation).
- Are not anticipated to cause the expected total noise levels to exceed the SMC maximum allowable noise limits.

At final design, a detailed noise analysis should be performed to confirm that the final design achieves these results. At that time, louver selection and HVAC fan selection might have to be adjusted to achieve similar project operational noise levels.

Figure 2 presents the project operational noise contours, based on the analysis and calculations described above. The figure also shows the locations of the noise sources, and discrete property line receptors. Figure 2 shows that project operational noise emissions affect a very small portion of the study area.

Figure 3 shows a close-up of the study area. Figure 3 shows that analysis results indicate that project operational noise levels will be low in areas of Seward Park that are not immediately adjacent to project related noise sources.

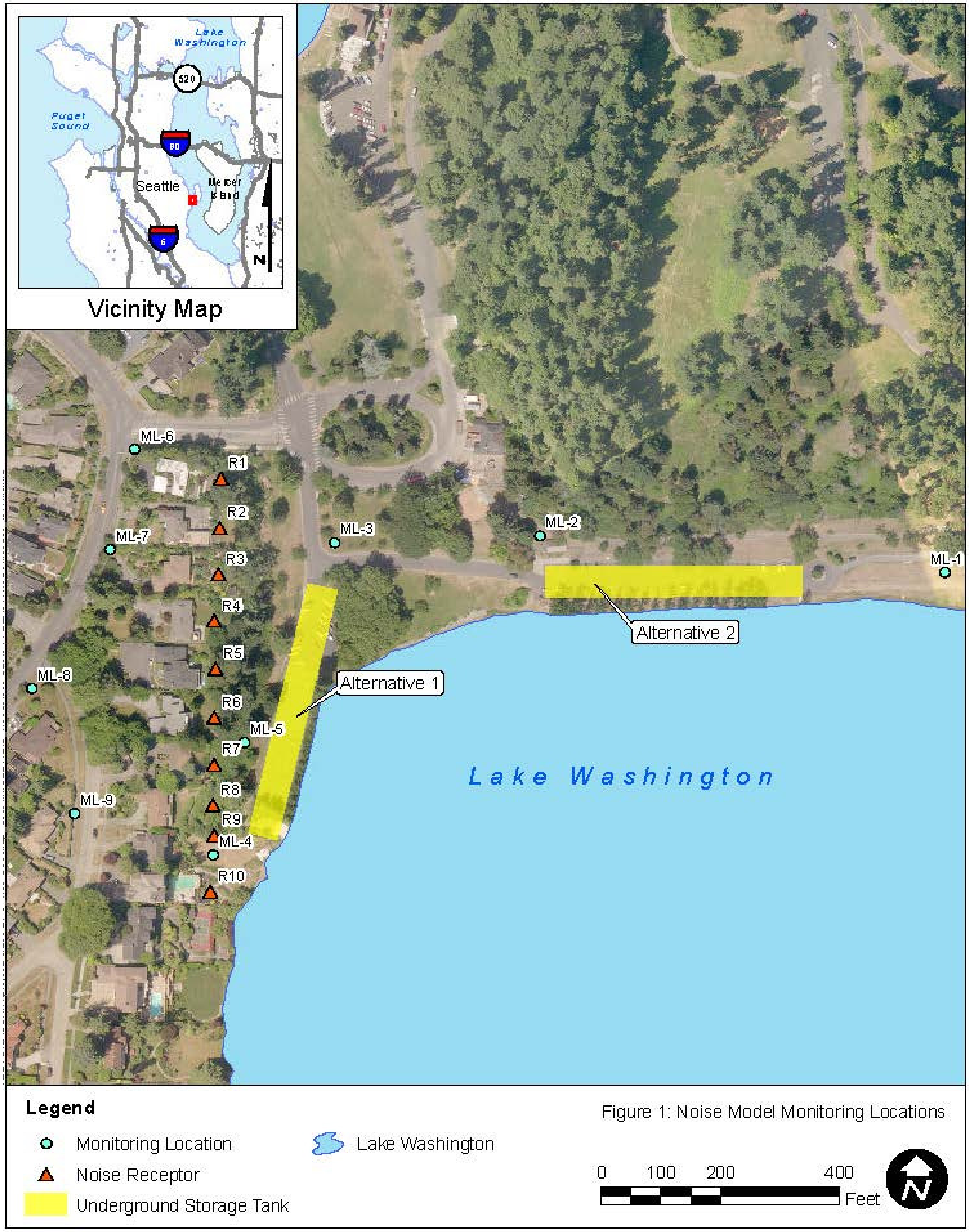

Figure 1 Noise Monitoring Locations

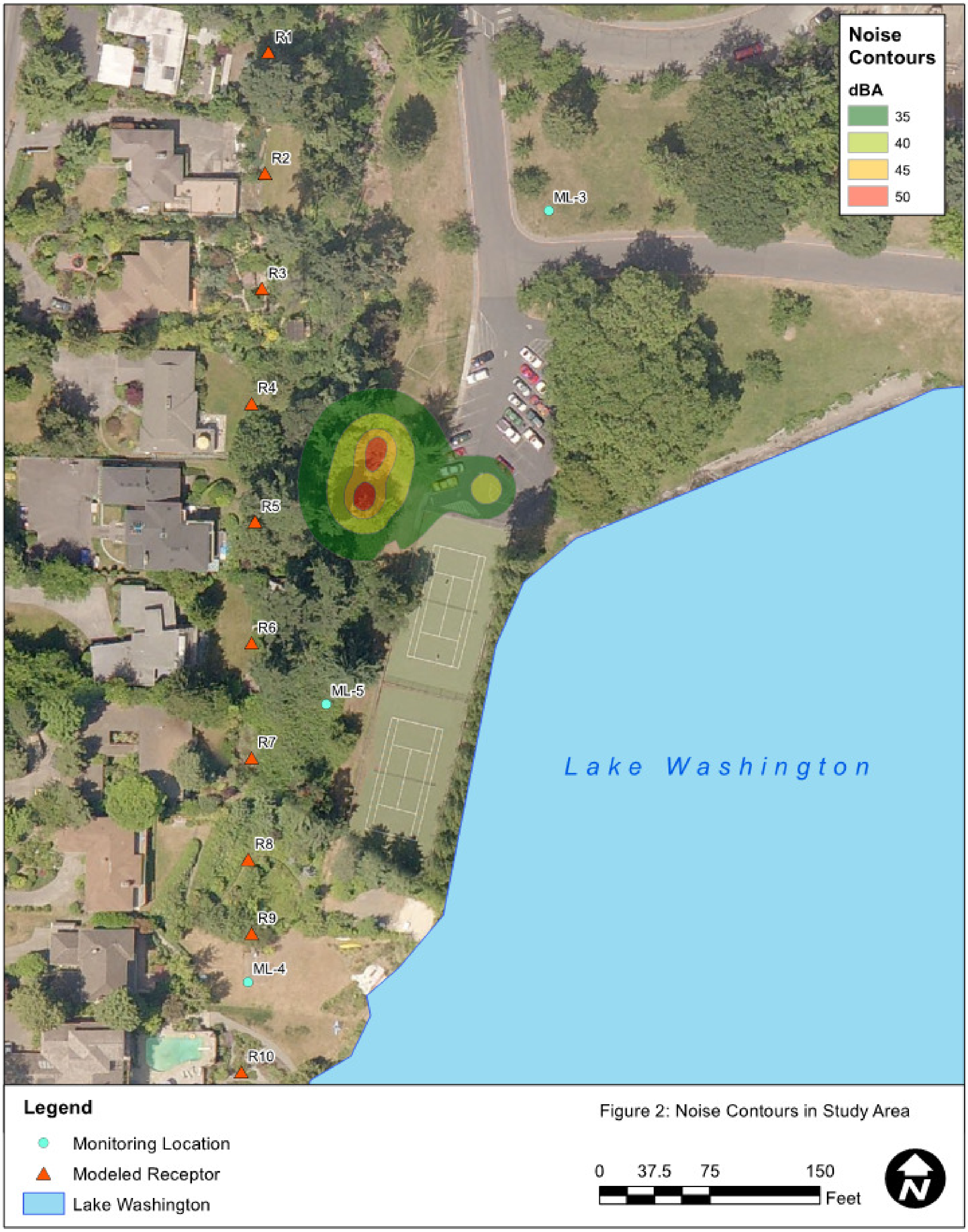

Figure 2 Noise Contours in the Study Area

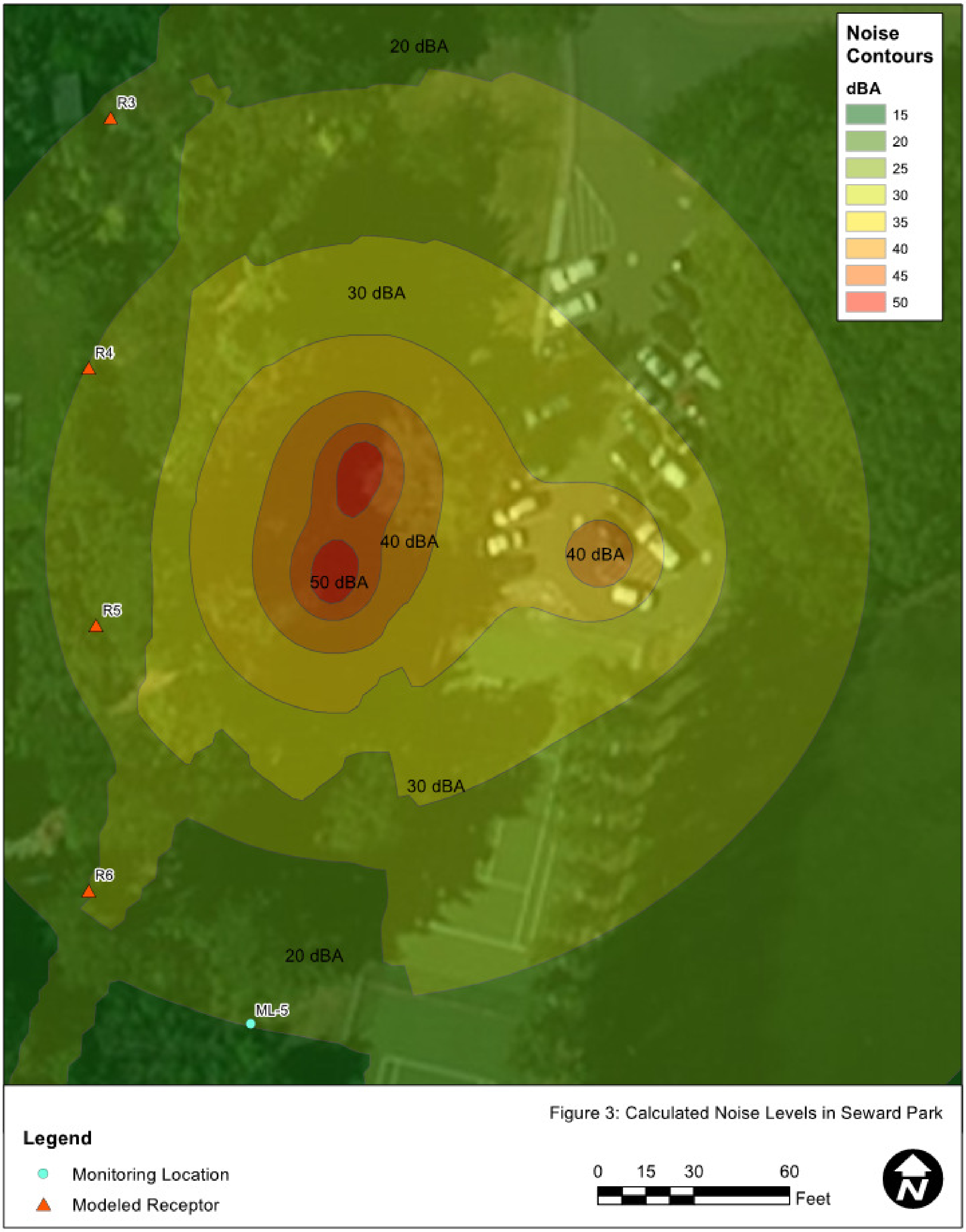

Figure 3 Calculated Noise Levels in Seward Park